Being optimistic about future prospects:

1: Falsifying classes of DE models
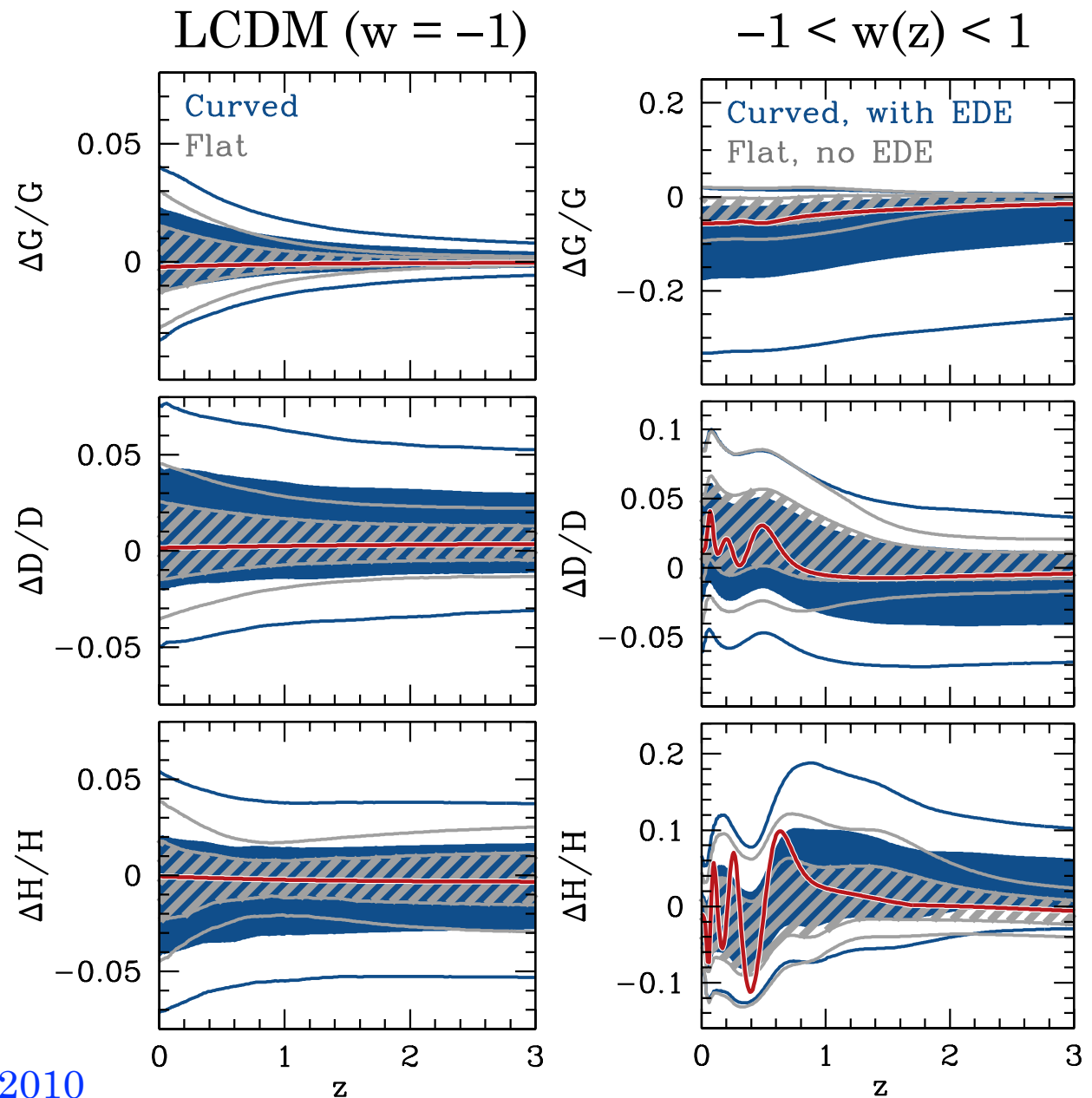
▶ Even rather general paradigms for cosmic acceleration (varying w, curved, early DE, ...) lead to rather tight predictions on observable quantities...

▶ ... and can therefore be ruled out with future distance + growth data
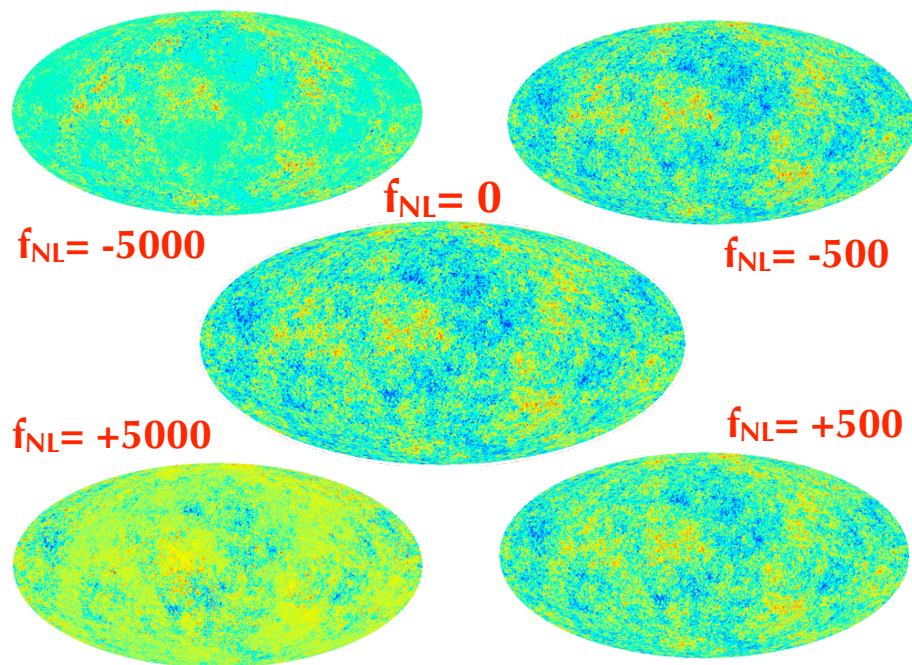
Falsifying classes of DE models

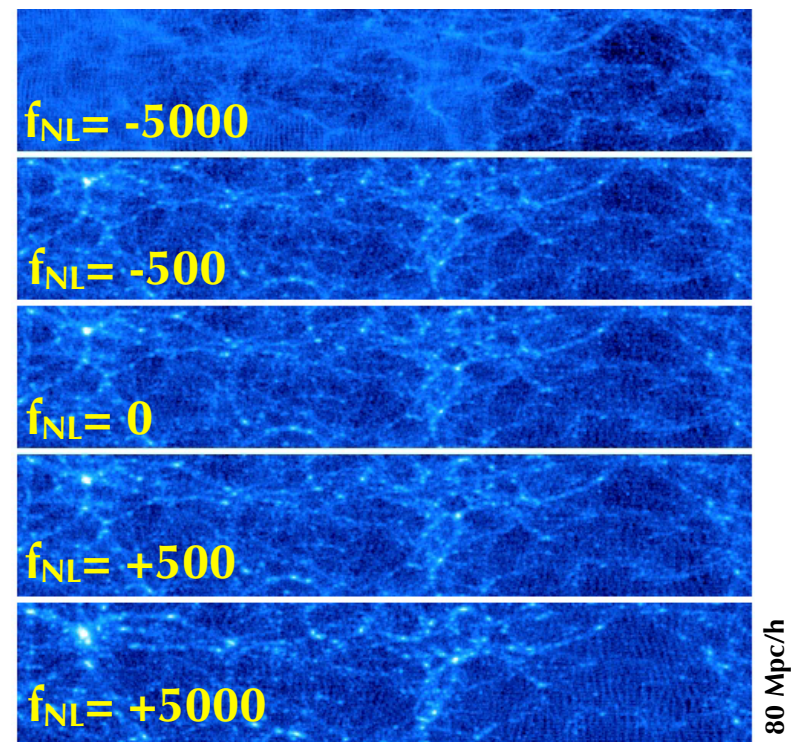# Being optimistic about future prospects:

2: Inner Space - Outer Space, circa 2020

Different observations on different scales with different systematics
but measuring the same fundamental quantities

Example: primordial non-Gaussianity

$f_{NL}= 0$

$f_{NL}= -5000$

$f_{NL}= -500$

$f_{NL}= +5000$

$f_{NL}= +500$

CMB

$f_{NL}= -5000$

$f_{NL}= -500$

$f_{NL}= 0$

$f_{NL}= +500$

$f_{NL}= +5000$

80 Mpc/h

375 Mpc/h

LSS

Example: using LSS to probe scale-dependent primordial non-Gaussianity

▶ Scale-dep NG models are motivated by particle theory (single-field inflation with self-interaction; mixed curvaton-inflaton models)

▶ Effects on LSS are significant, but theory predictions are uncertain ⇒ ongoing theoretical and simulation work

▶ Understanding of astrophysics (of DM halos, etc) required in order to probe fundamental physics

Scale-dep. ansatz:

$$f_{\mathrm{NL}}(k) = f_{\mathrm{NL}}(k_p) \left(\frac{k}{k_p} \right)^{n_f} .$$

Halos of mass M probe NG on scale k~M$^{-1/3}$

Shandera, Dalal & Huterer, 2011
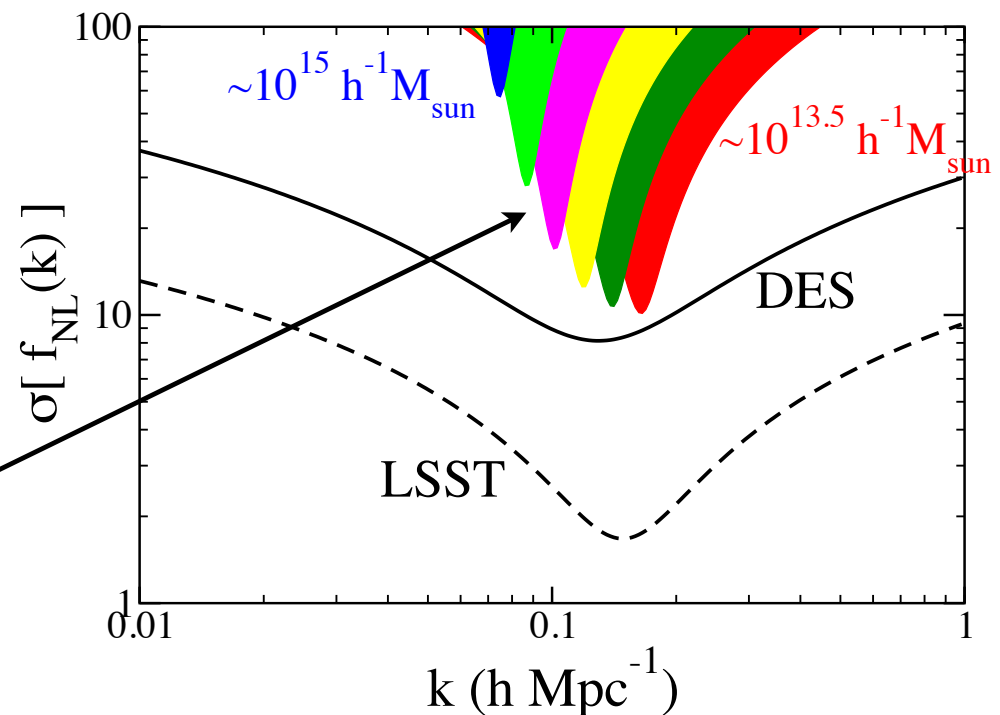
I. Margins

- The easiest and cheapest way(s) to increase your forecast DE FoM within finite resources are to:
  - Switch from N σ $\rightarrow$ ($N-1$) σ detections.
  - Ignore the greatest number of losses in your system.
  - Assume that a $>>10σ$ systematic error will be estimated statistically and subtracted.

- This is not the way to construct a robust DE program!
  - But there is a real danger that this is what FoM-based "optimizations" will give us.
  - … and then reality will come and we will lose some throughput, have to reject some data, …

II. Understanding & Controlling Systematic Errors

- This is critical. (I think we all at least nominally get this.)

- Understanding is key – not just philosophizing.
  - Systematics not just a function of headline technique.
  - How do you know you didn't just get lucky last time/won't break something?

- We don't have enough people working on this and don't use the ones we have effectively. Why not?

  [My possibly biased answers as a weak lensing person; I am guilty of all of these.]
  - Perception that you will be invisible and won't get a job.
  - Risk: what happens to me if I personally don't solve the problem in <3 years, or the future project using X method get axed?
  - Graduate/postdoc education rarely emphasizes the fundamental reasons why algorithms work or don't. WL is largely algorithm limited – too much time is spent using/perturbing canned/hacked algorithms that need to be replaced with custom tools.

III. The Space Mission

- Dark energy did very well in Astro2010. Both ground (LSST) and space (WFIRST) priorities highly relevant to DE.

- DE is one of several objectives – it does not get all 5 years.
  - The demand by many users is a good thing!
  - No whining, please!

- Fitting all 3 techniques in the timeline:
  - Will be a challenge
  - Is recognized as needed to achieve full potential of SN + WL + BAO
  - Won't give us everything an optimized 1-technique mission could do
  - Will make major advances in volume/quality over what can be done from the ground <u>alone</u> (but synergy with LSST is essential)

- Uncertainties:
  - Would like to collaborate with Europe, but there have been challenges.

What limits the science?

Quiescent Galaxy

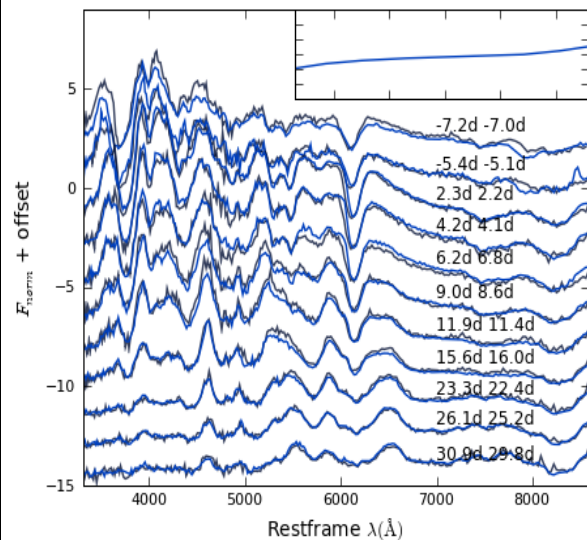Star forming Galaxy

Model Mags

CModel Mags

Scranton et al 2005
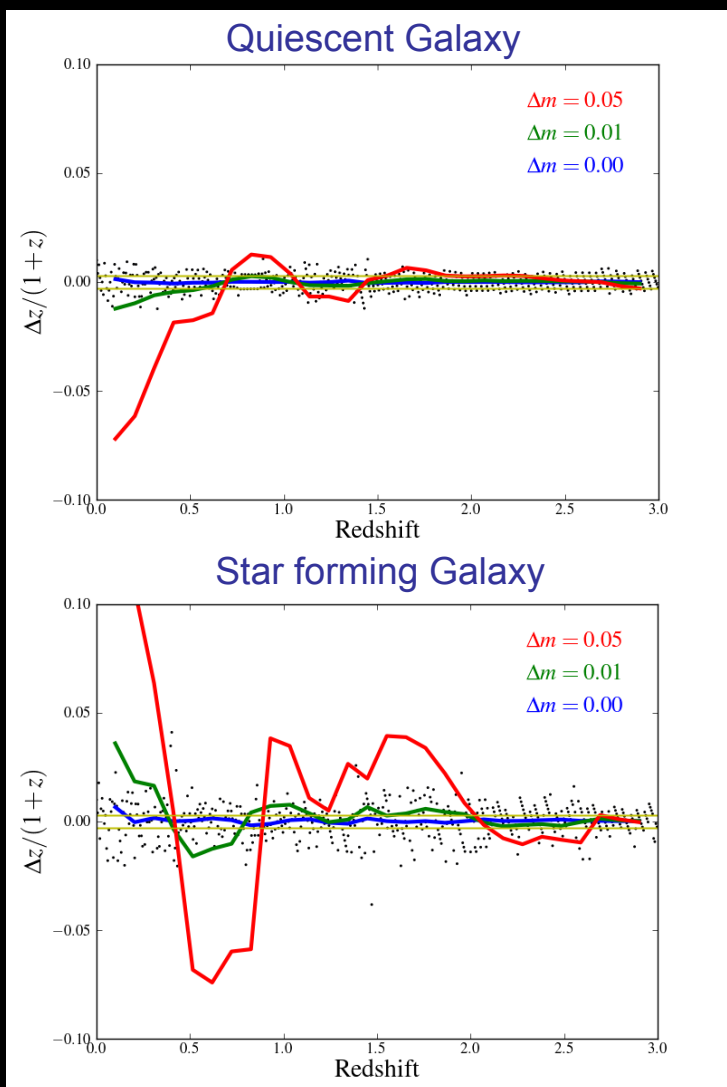
Photometric Calibration – offsets introduce bias in redshift estimation
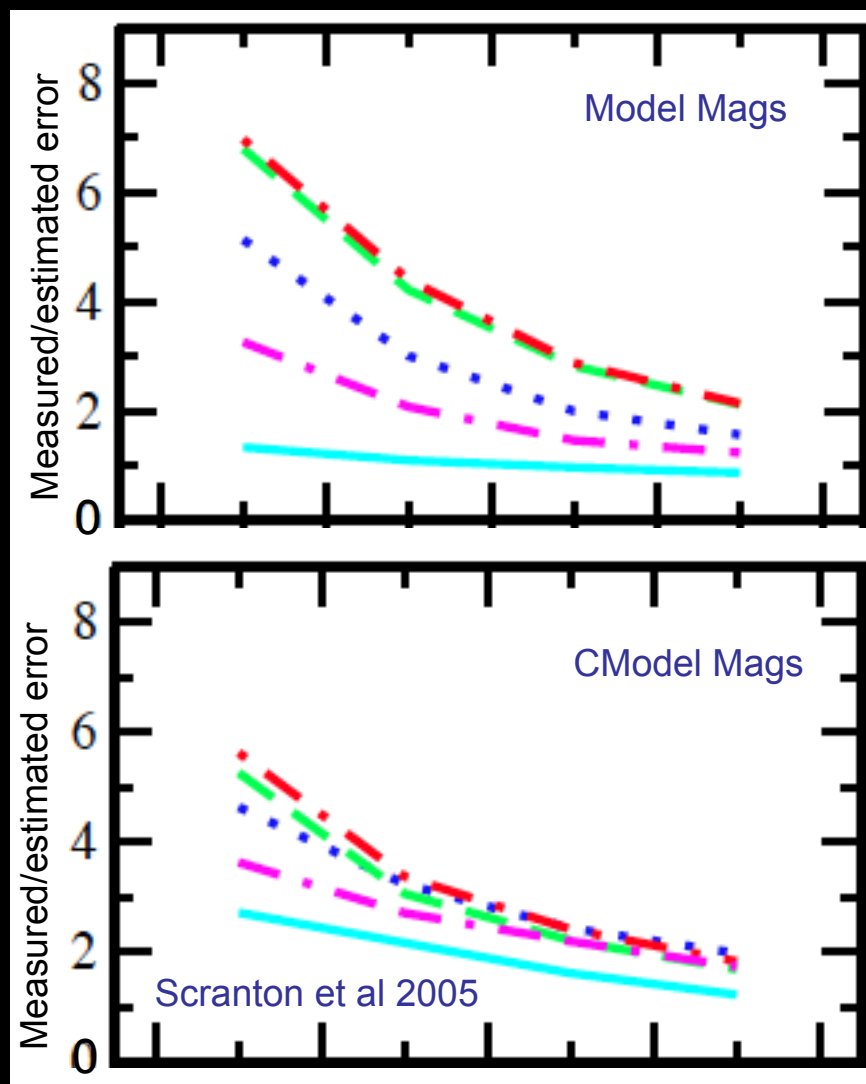
Error Estimation – color dependence in the estimation of photometric errors
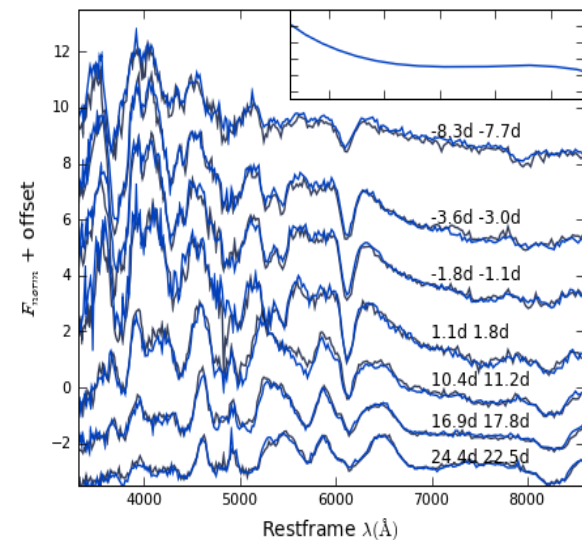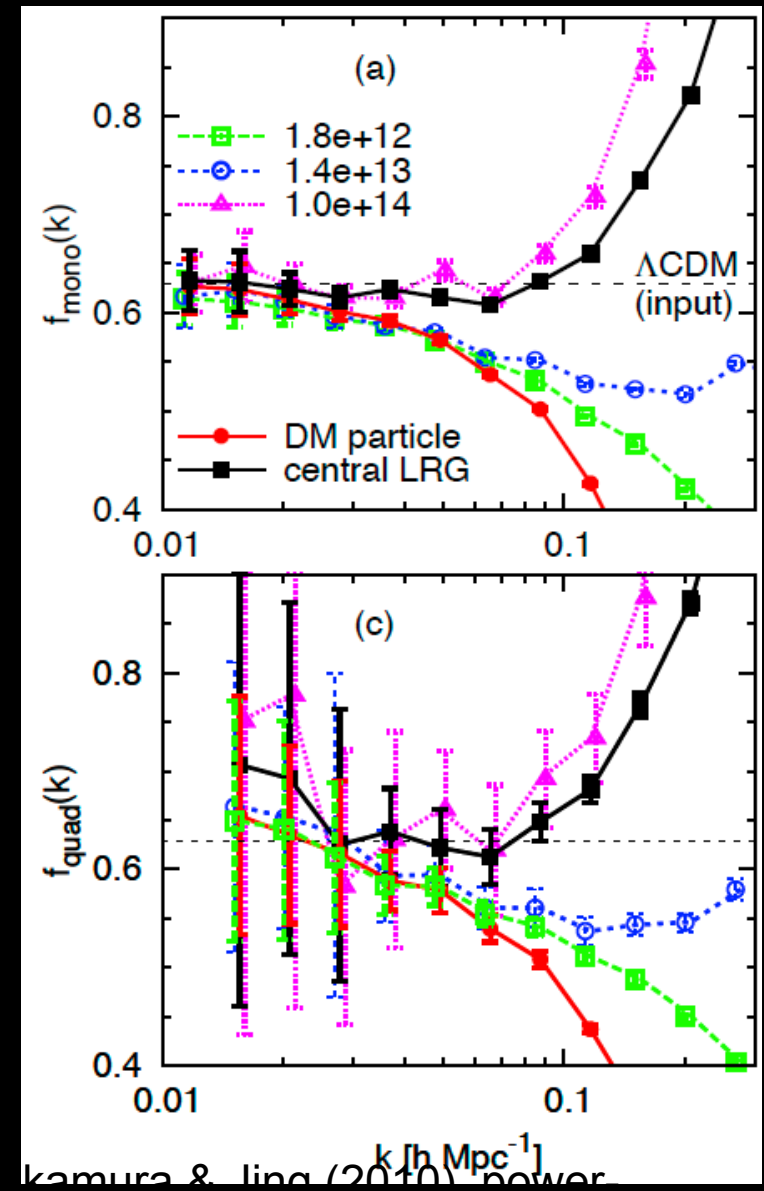
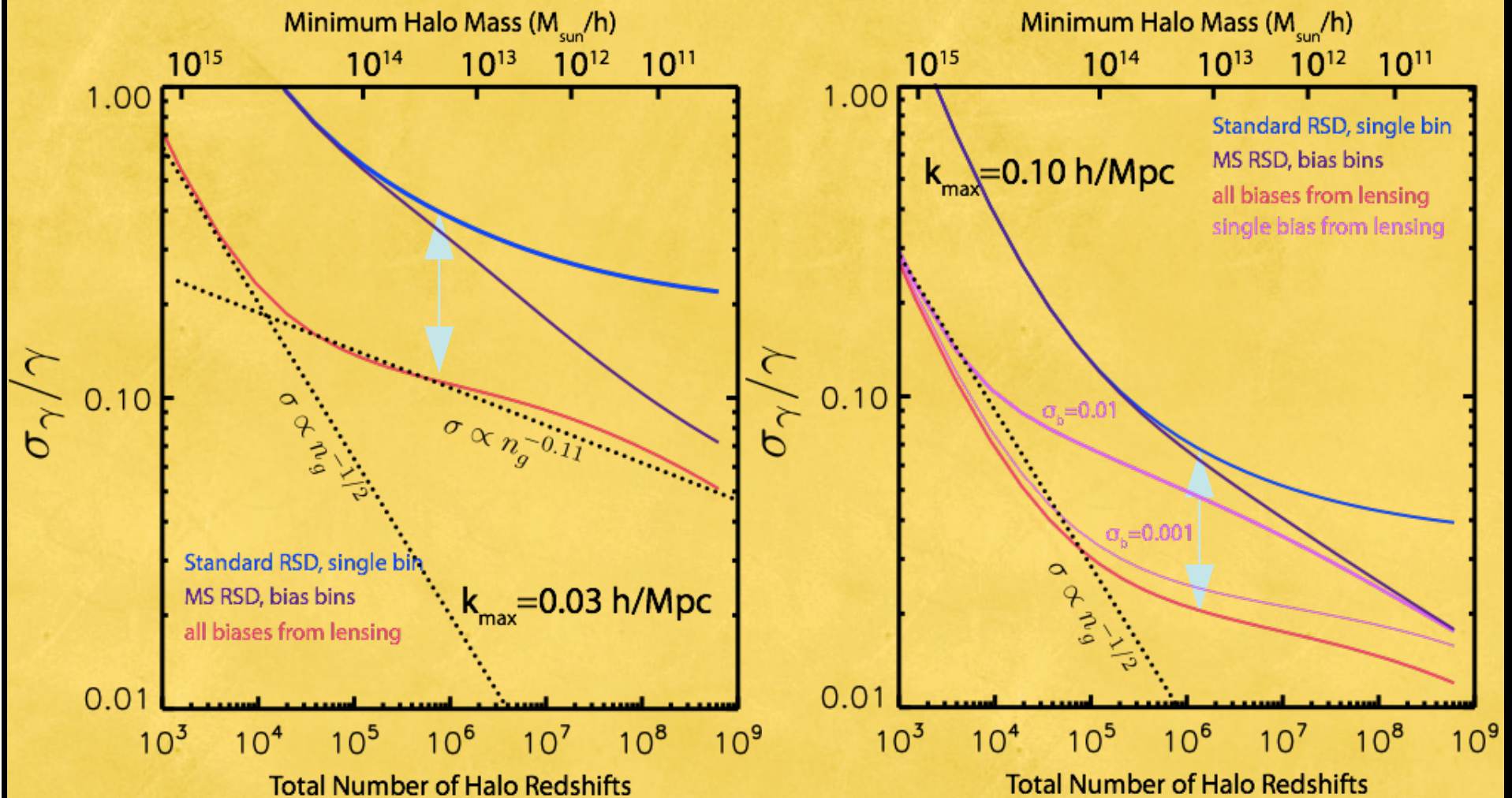# SN Twins
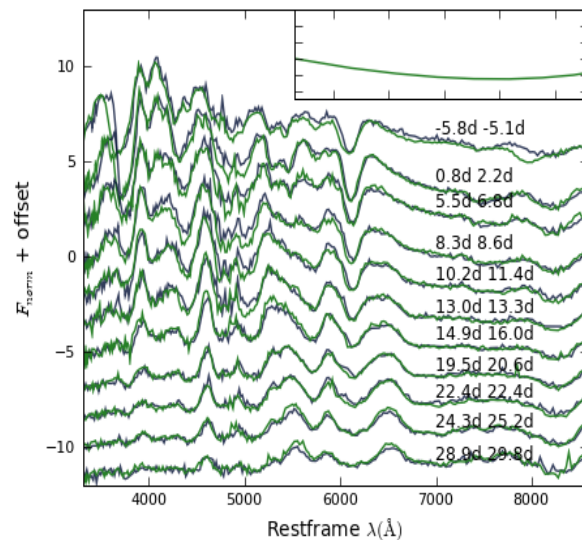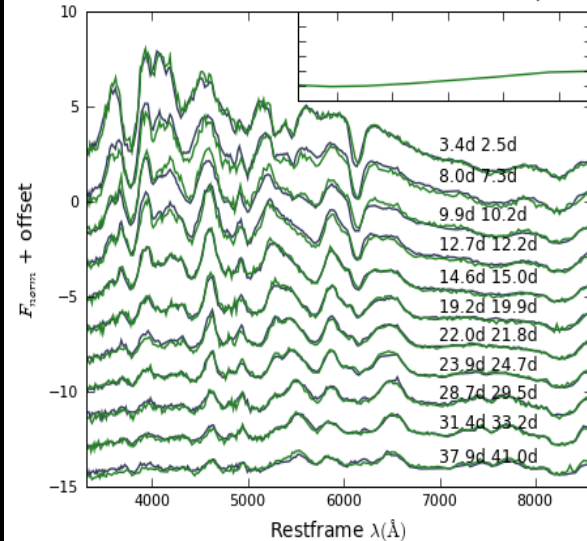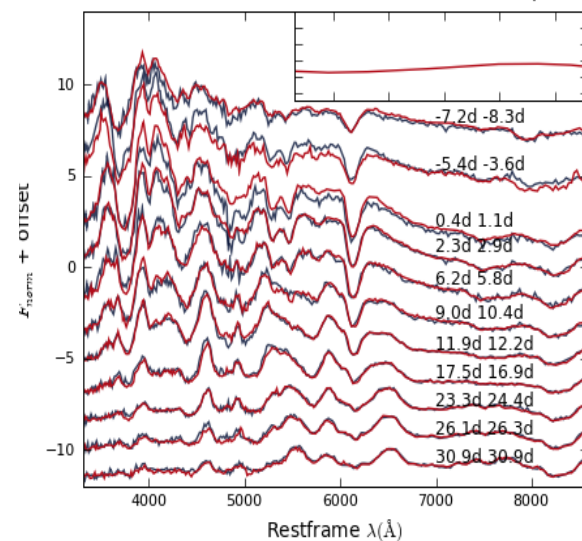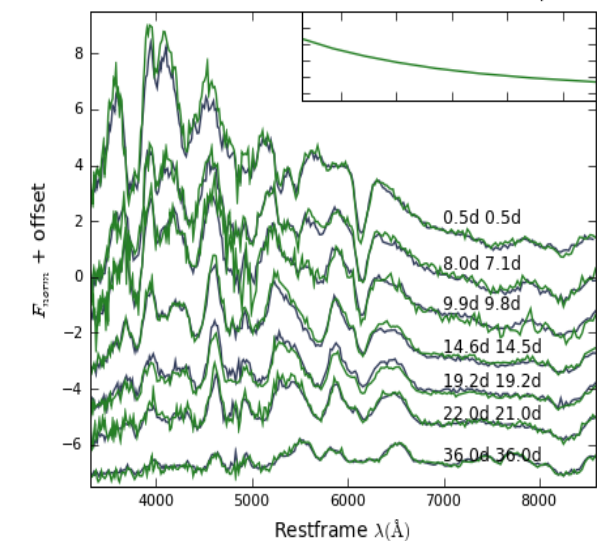
Difficulties with standard RSD technique:

$$P_s = (b + f\mu^2)^2 P = f^2 P \left[b/f + \mu^2\right]^2$$

- *f* is degenerate with *b*. Can extract *f²P =f²G²P₀.*

- Kaiser formula valid only on very large scales, *k<0.1h* Mpc⁻¹ at best?

- *Sample Variance!*

$$\sigma_{\ln fG} \geq \sqrt{11/N_m}$$

kamura & Jing (2010) power

WL data increases effective volume of RSD 10-fold

Assuming 1/2-sky survey of z=0.5±0.05

Questions for discussion

- **What is the post-DES, post-BOSS goal? Seeking w!=-1? Or tests of GR? Falsifying specific other models? Do these need distinct experiments or have different prospects?**
- **Are we prepared to deal with reduction of LSST data? What techniques & strategies are essential to get what we can from ground-based visible imaging surveys?**
- **If LSST goes forth, what additional data are *necessary* to enable a great advance in DE constraints over DES/BOSS?**
- **What are the essential, most productive aspects of the future experimental program?**